



# Trends in Nitrate and other Nutrients in the San Joaquin River, California

ASA-CSSA-SSSA 2007 international annual meetings  
New Orleans, LA  
November 6, 2007

Charlie Kratzer and Dina Saleh  
U.S. Geological Survey  
Sacramento, CA

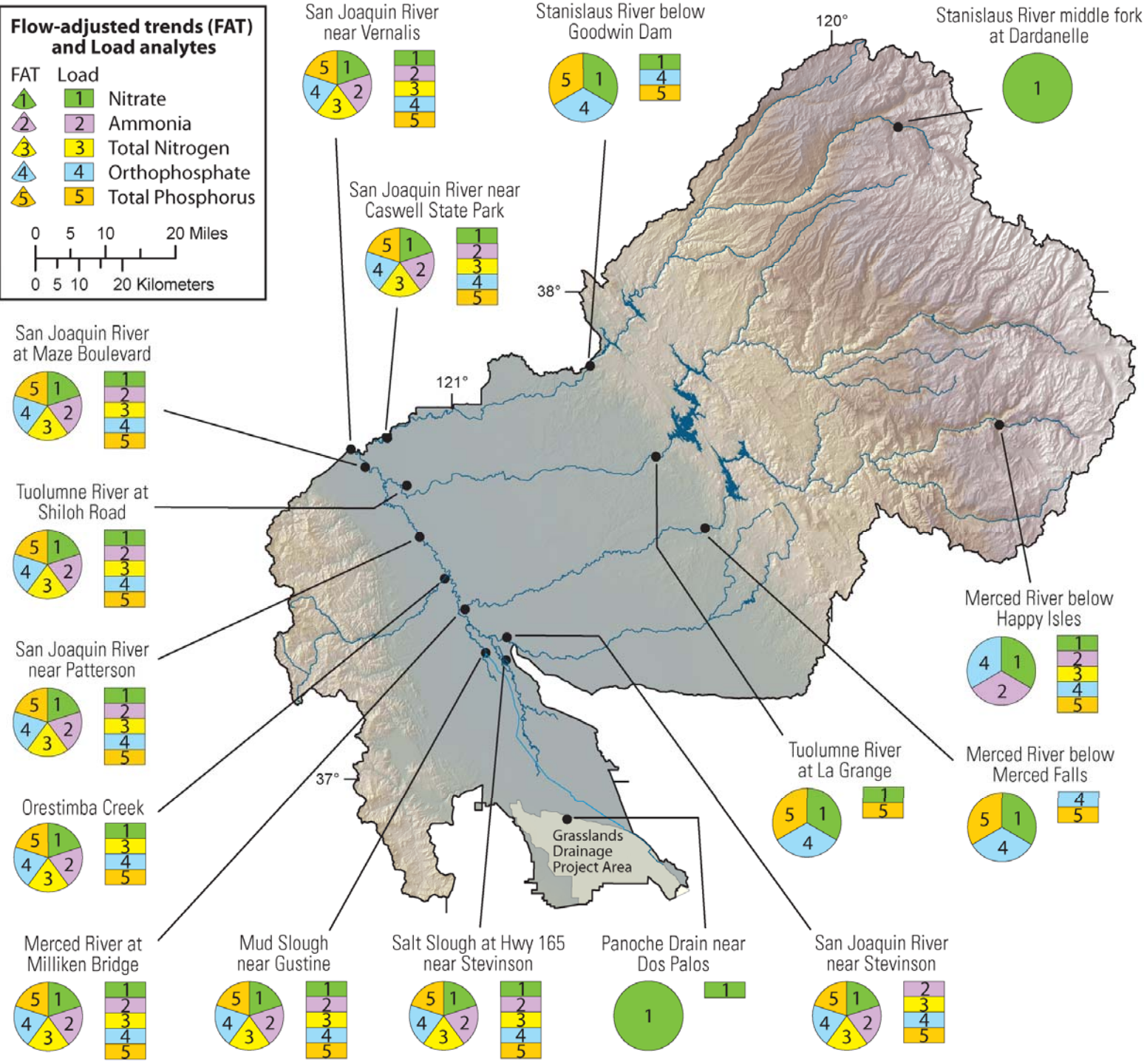
# Outline

- Data
- Analysis Method
- Trends in Stream Concentrations
- Trends in Sources
- Loads
- Yields and Percent Delivery
- Conclusions

# Data

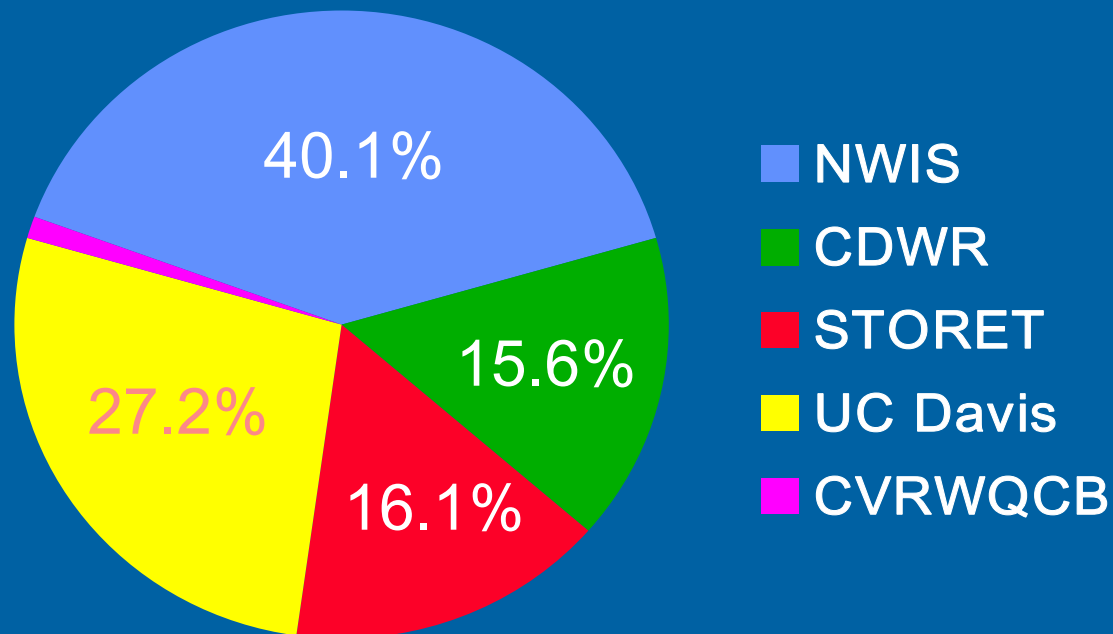
# SJB sites:

Sites with enough data during 1975-1975-2004 to calculate flow-adjusted trends (FAT) in concentrations (n=16) or estimate loads (n=15)

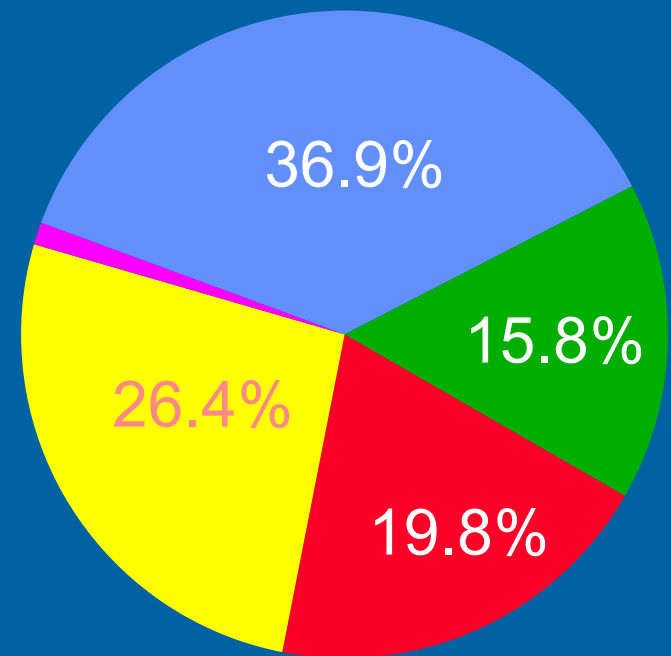


# Sources of Final Nutrient Concentration Data for 1975 to 2004

Total number of analyses for nitrate, ammonia, and total nitrogen = 11,217



Total number of analyses for orthophosphate and total phosphorus = 7,704



# Analysis Method

- **Loads**

- S-LOADEST; log-linear multiple regression model based on relation between flow and concentration
- requires streamflow data for every day; >4 samples/yr for at least 2 yrs; significant data at beginning and end periods of at least 5 year time period

- **Trends**

- uses time coefficients of the S-LOADEST model

- **Advantages and Acceptability Criteria**

- accepts <'s, uses all the data, gives a CI for loads and slopes of trends ( $95\% \text{ CI} = \pm 1.96 * \text{SEP}$ )
- Standard Error of Prediction (SEP)<30% considered good
- $30\% < \text{SEP} < 50\%$  considered questionable, but useable
- SEP is impacted by data gaps (moderate impact in middle of load period; large impact at beginning/ending of load period)

# Trends in Stream Concentrations



# Nutrient Trends in SJB, 1975-2004

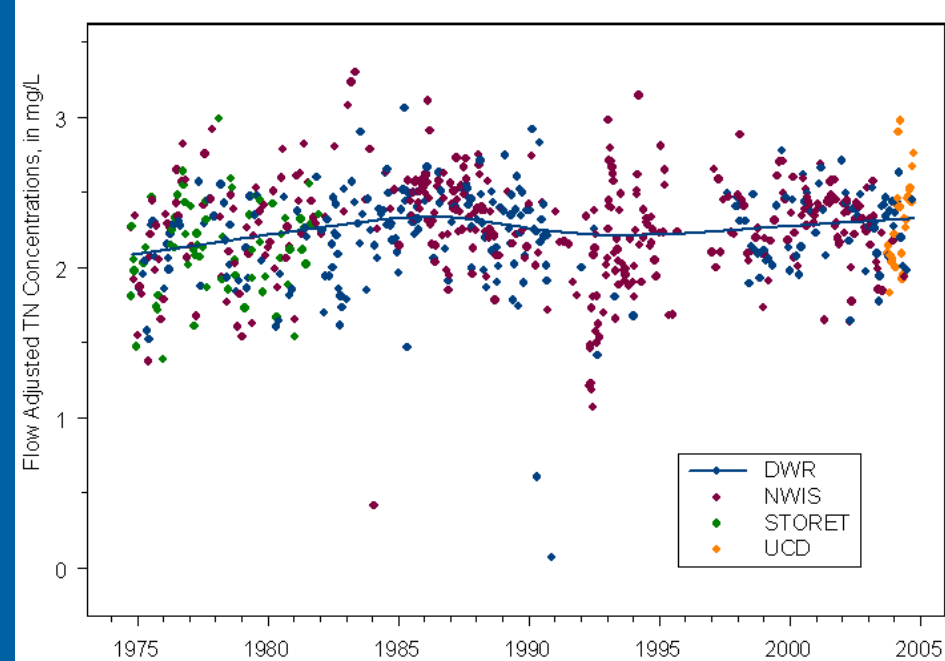
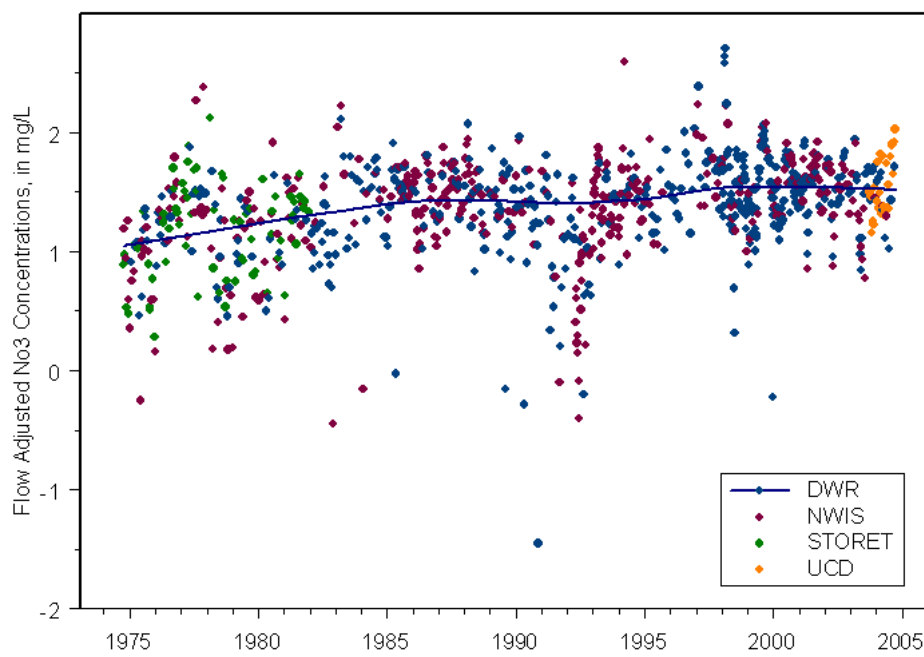
Site	NO3	NH4	TN	OP	TP
SJR nr Stevenson					
Salt Slough					
Mud Slough					
Merced R					
Orestimba Creek					
Tuolumne R					
Stanislaus R					
SJR nr Vernalis					

	Upward trend (slope > 5 %/yr)
	Upward trend (slope < 5 %/yr)
	No significant trend (p > 0.05)
	Downward trend (slope < 5 %/yr)
	Downward trend (slope > 5 %/yr)

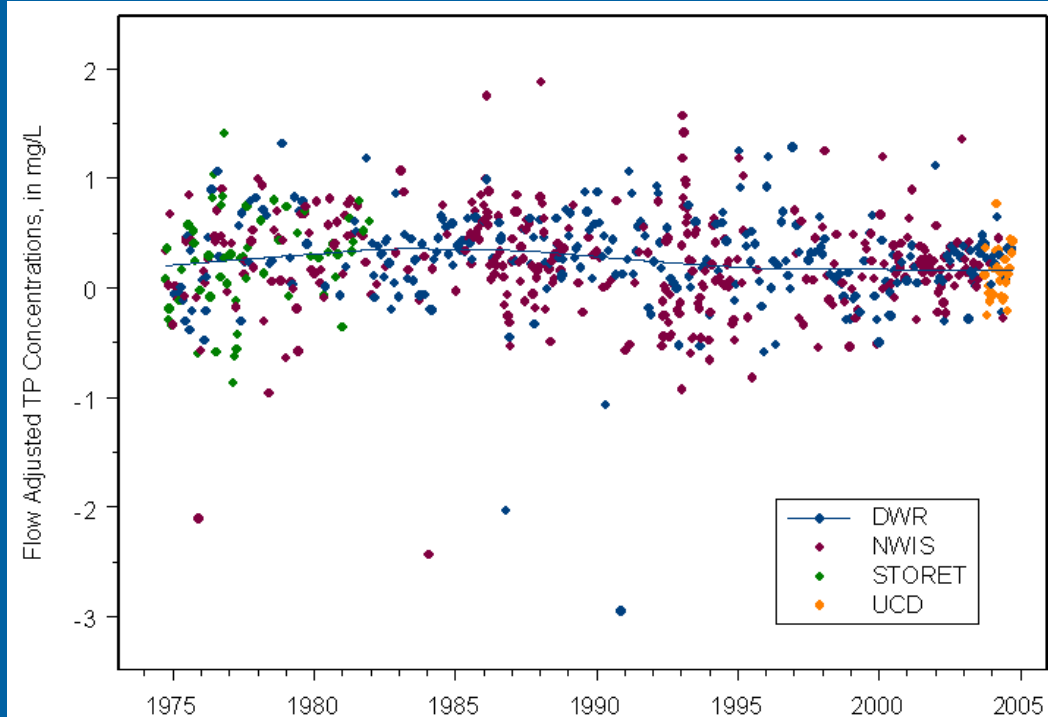
# Nutrient Trends in SJB, 1985-2004

Site	NO3	NH4	TN	OP	TP
SJR nr Stevinson					
Salt Slough					
Mud Slough					
Merced R					
Orestimba Creek					
Tuolumne R					
Stanislaus R					
SJR nr Vernalis					

	Upward trend (slope > 5 %/yr)
	Upward trend (slope < 5 %/yr)
	No significant trend (p > 0.05)
	Downward trend (slope < 5 %/yr)
	Downward trend (slope > 5 %/yr)

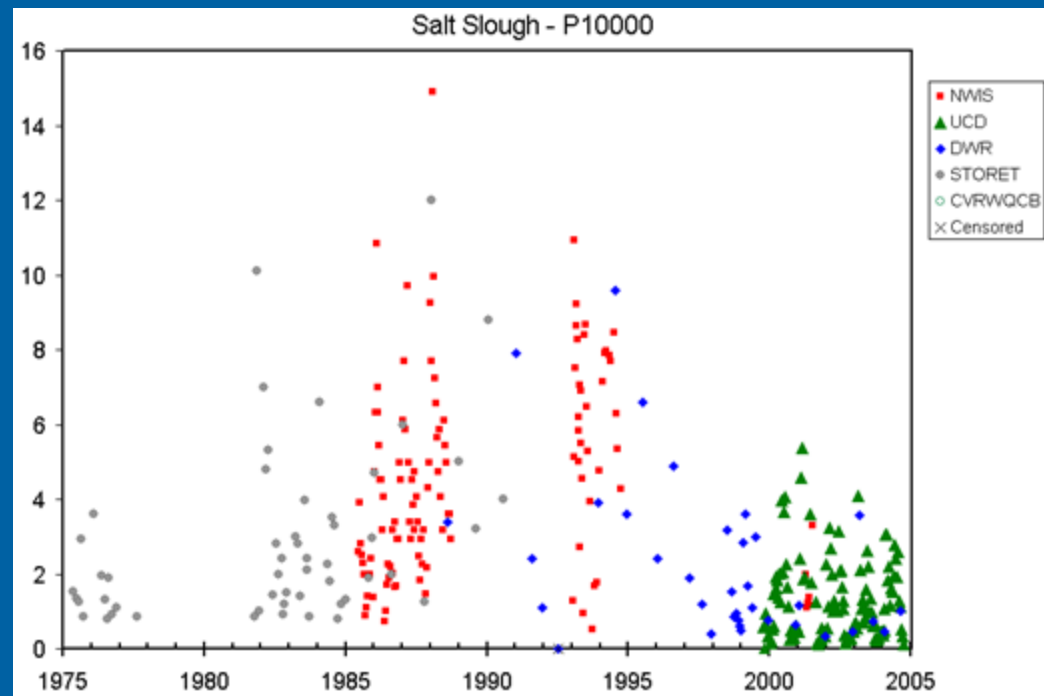
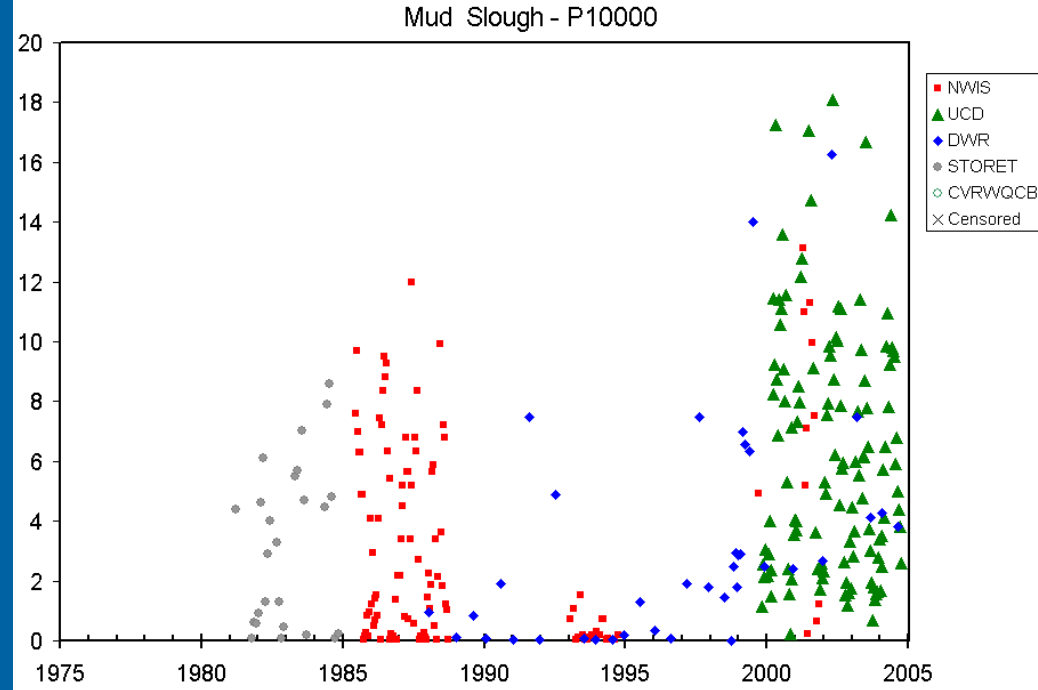


# Flow-adjusted concentrations in SJR near Vernalis for NO<sub>3</sub>, TN, and TP (1975-2004)



# Non-flow-adjusted nitrate concentrations in Mud Slough and Salt Slough, 1975- 2004

GBP diverted tile  
drainage from Salt  
Slough to Mud  
Slough starting in  
1997



# Trends in Sources

# Sources

- **Point Sources**

- from self-reported regulatory files in state offices

- **Atmospheric Deposition**

- for wet deposition we used data on nitrate and ammonia from 2 NADP sites (85-04), 3 CADMP (CARB) sites (85-94), and 1 CASTNET (USEPA) site (96-04)

- for dry deposition we used data on gaseous  $\text{HNO}_3$  and particulate  $\text{NO}_3$  and  $\text{NH}_4$  from 3 CADMP (CARB) sites (88-94) and 1 CASTNET (USEPA) site (96-04)

- both wet and dry data was related to a NADP wet dep site (85-04) to calculate total atm dep values for 85-04; dry/wet (SJB)  $\sim 2.8$

NADP – National Atmospheric Deposition Program; CADMP – California Acid Deposition Monitoring Program; CARB – California Air Resources Board; CASTNET – Clean Air Status and Trends Network

# Sources (cont.)

- **Fertilizer Application**

- used data from NAWQA Nutrients National Synthesis disaggregation of county-level data to basin areas

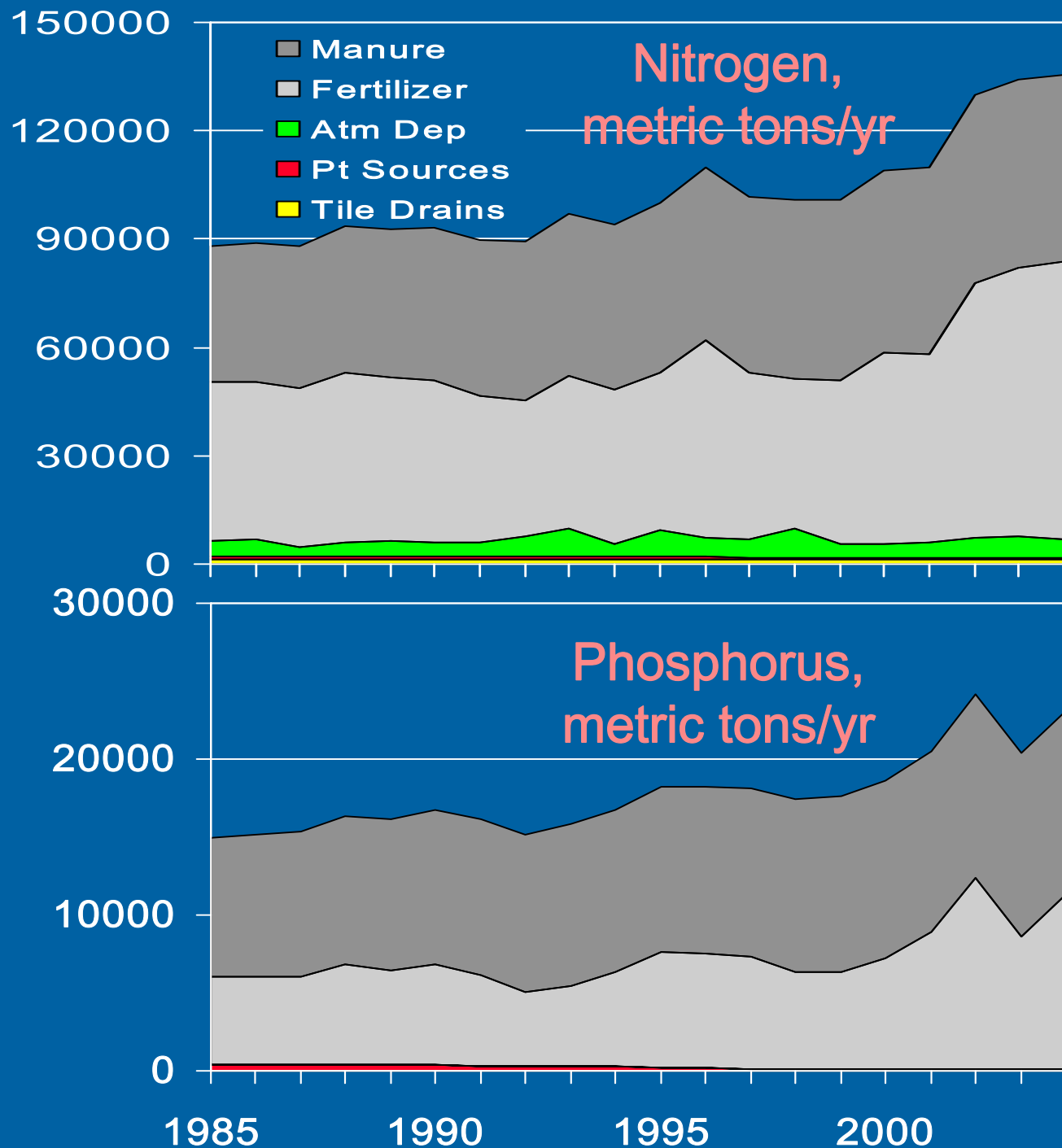
- **Manure Production**

- used data from NAWQA Nutrients National Synthesis disaggregation of county-level data to basin areas

- **Tile Drainage**

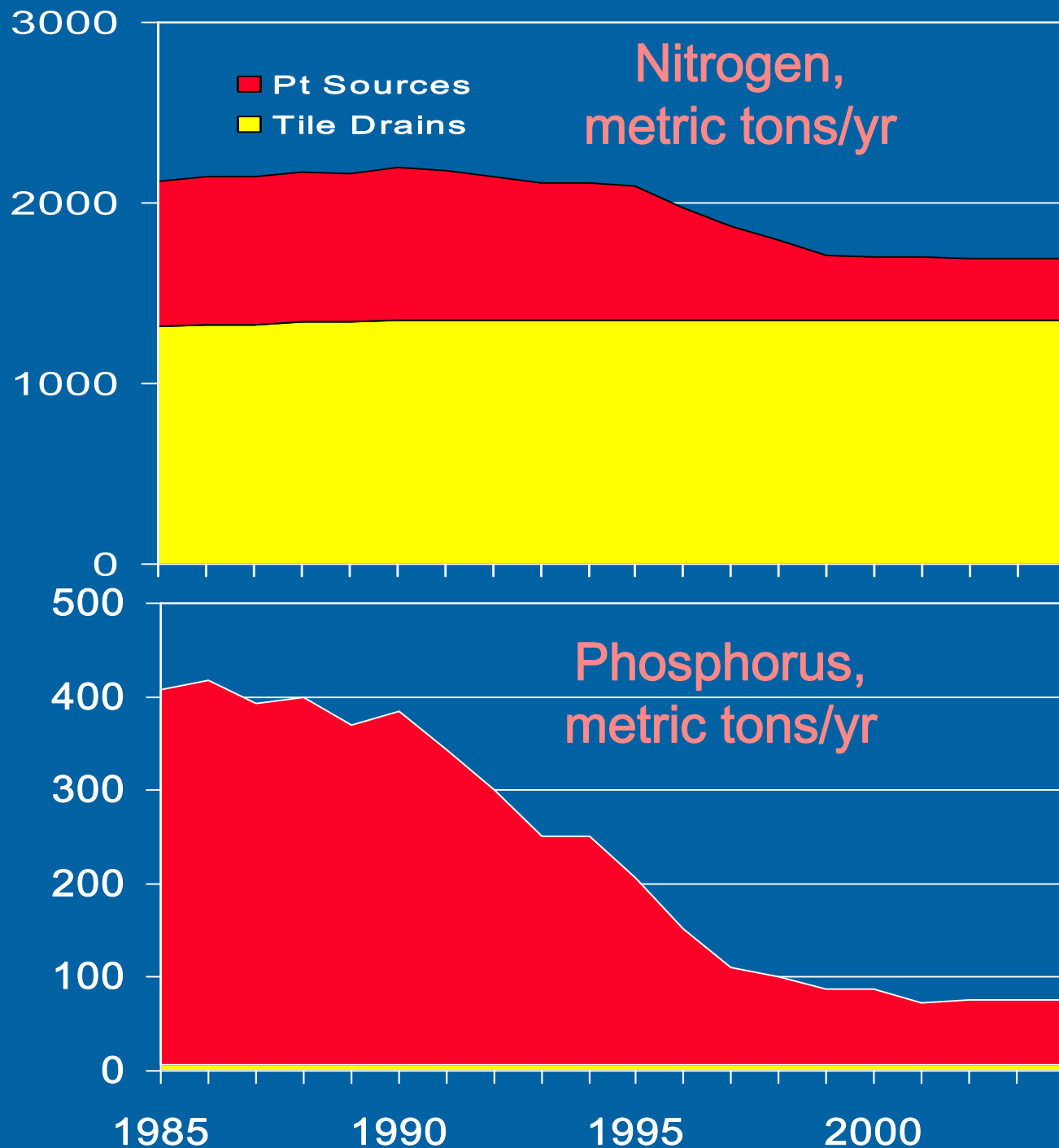
- used information on installation of drains for 1950-91 from the state with a drainage factor of 0.7 af/ac (0.2 m) and TN= 25 mg/L to estimate tile drainage load to SJR

Indirect  
(manure, fertilizer, atm  
dep) and  
Direct (point  
sources, tile  
drains)  
Sources of  
Nutrients in  
SJB, 1985 to  
2004



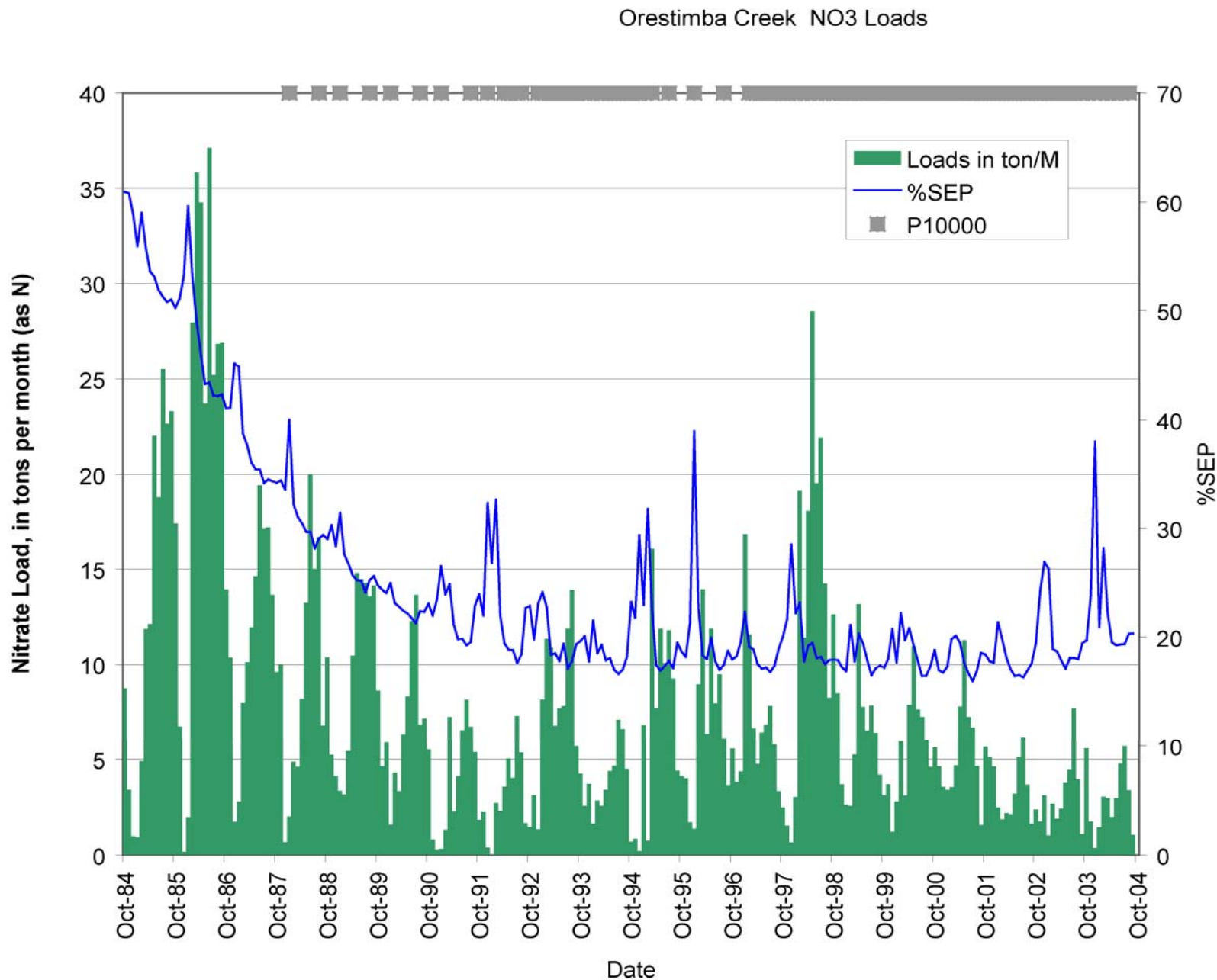


Direct (point  
sources, tile  
drains)  
Sources of  
Nutrients in  
SJB, 1985 to  
2004

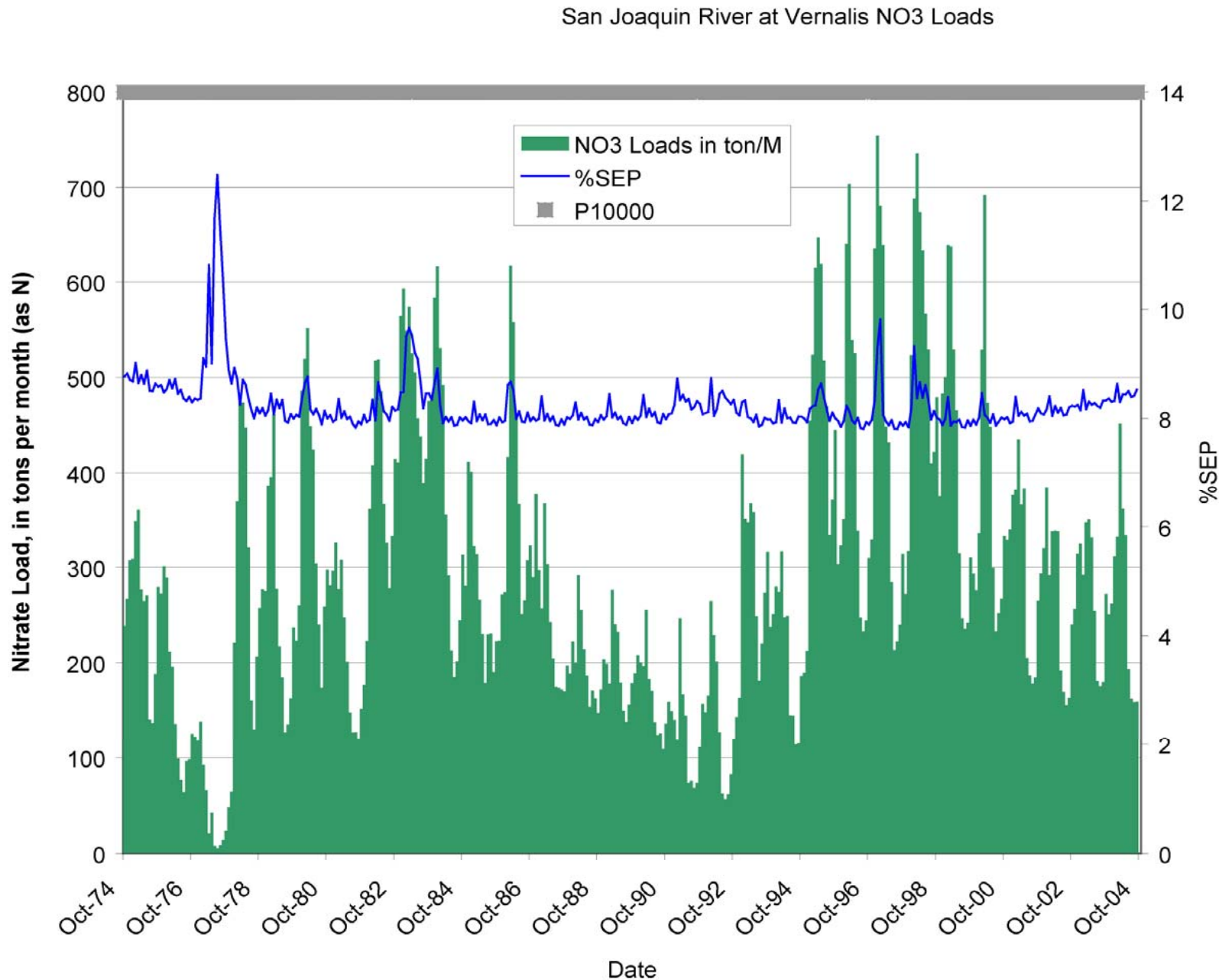


# Loads

# Example of uncontrolled SEP at beginning of time period

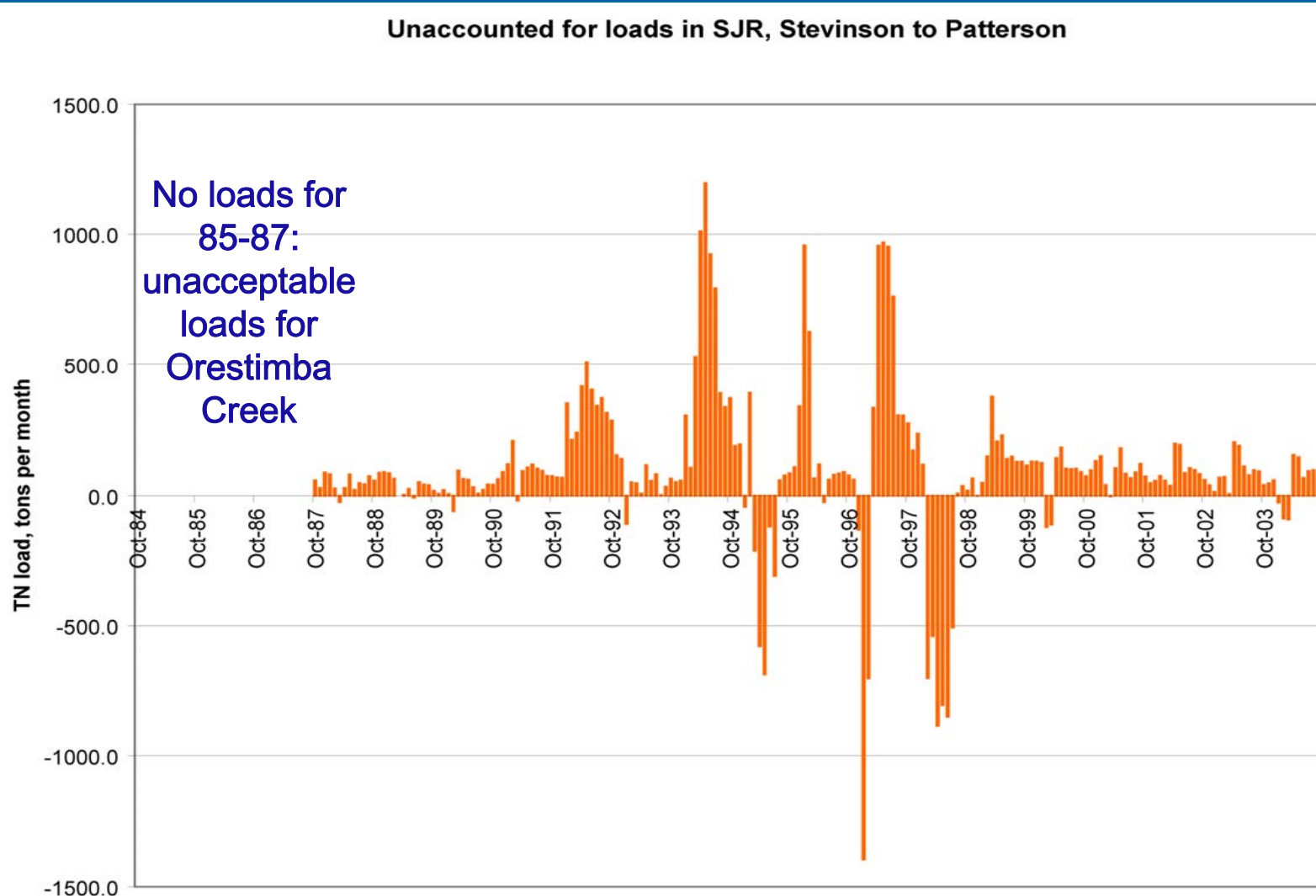


# Example of great load estimates



# Mass balance on loads between mainstem sites allows calculation of yield for ungaged/unsampled basins

$$\text{SJR nr Patterson (unaccounted for)} = \text{SJR nr Patterson} - [\text{SJR nr Stevenson} + \text{Salt SI} + \text{Mud SI} + \text{Merced R} + \text{Orestimba Cr}]$$



# Comparison of TN and TP Average (2000-level) Sources and Loads, in metric tons/yr

Source	TN	TP
Manure	50,800	11,400
Fertilizer	52,500	8,200
Atmospheric Deposition	5,100	0
Point Sources	370	80
Tile Drainage	1,350	5
River Loads	6,300	750
Percent Delivery (all)	5.7%	3.8%
Percent Delivery (indirect)	4.2%	3.4%
River flow-wt conc	1.46 mg/L	0.17 mg/L

Percent Delivery = [River Load/All Sources](all) = [(River Load – Direct Sources)/Indirect Sources](indirect)

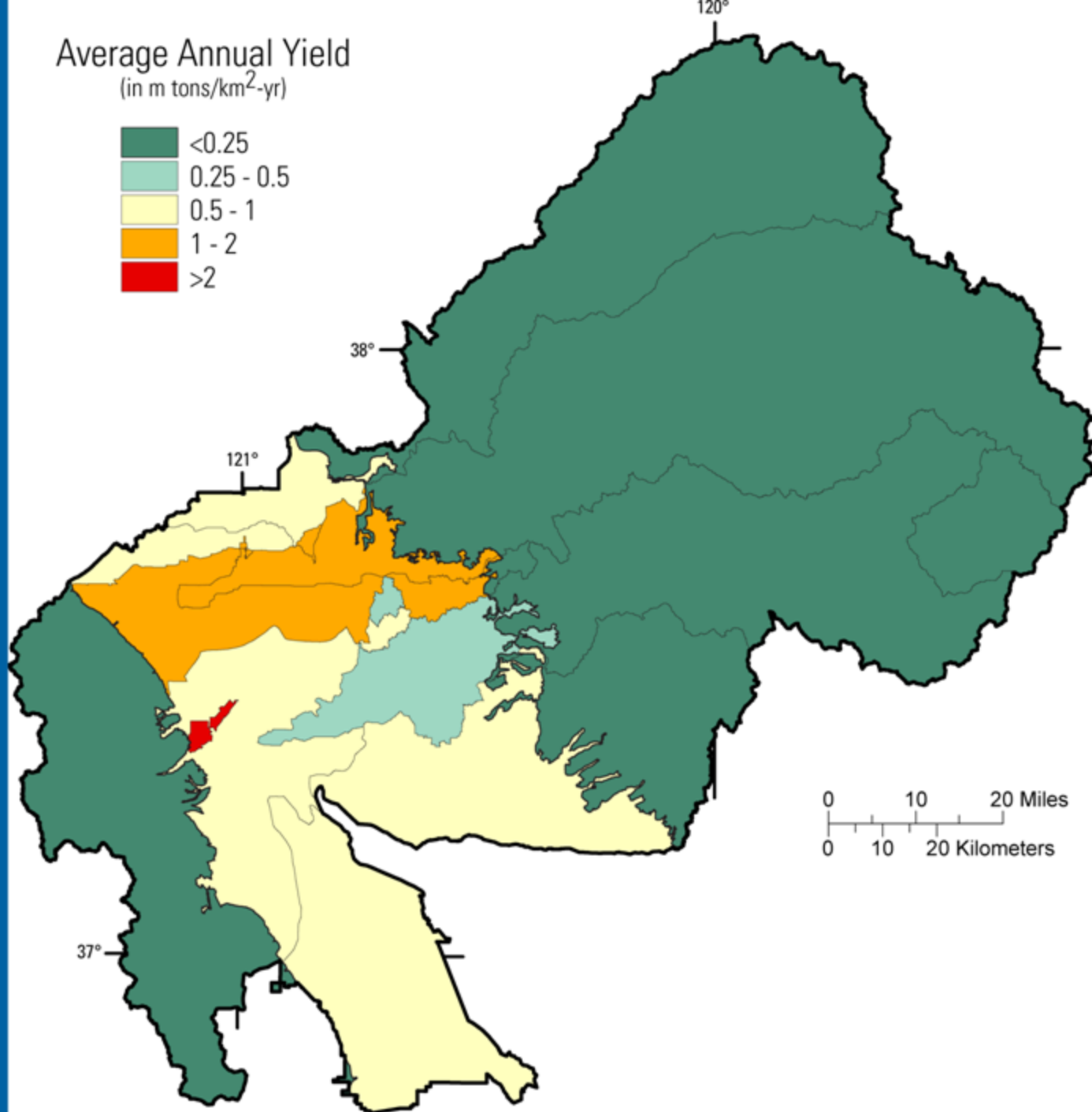
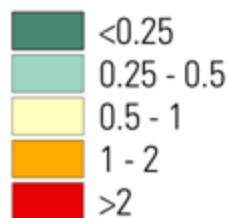


C (mg/L) = 11.57 [L(Mt/d)/Q(cms)] = 370.6 [L(t/d)/Q(cfs)]; (Q = 137 cms; 4,828 cfs)

# Yields and Percent Delivery

Yields of TN  
by drainage  
basin, in  
categories  
of <0.25;  
0.25-0.5;  
0.5-1; 1-2;  
and >2  
metric  
tons/km<sup>2</sup>-yr

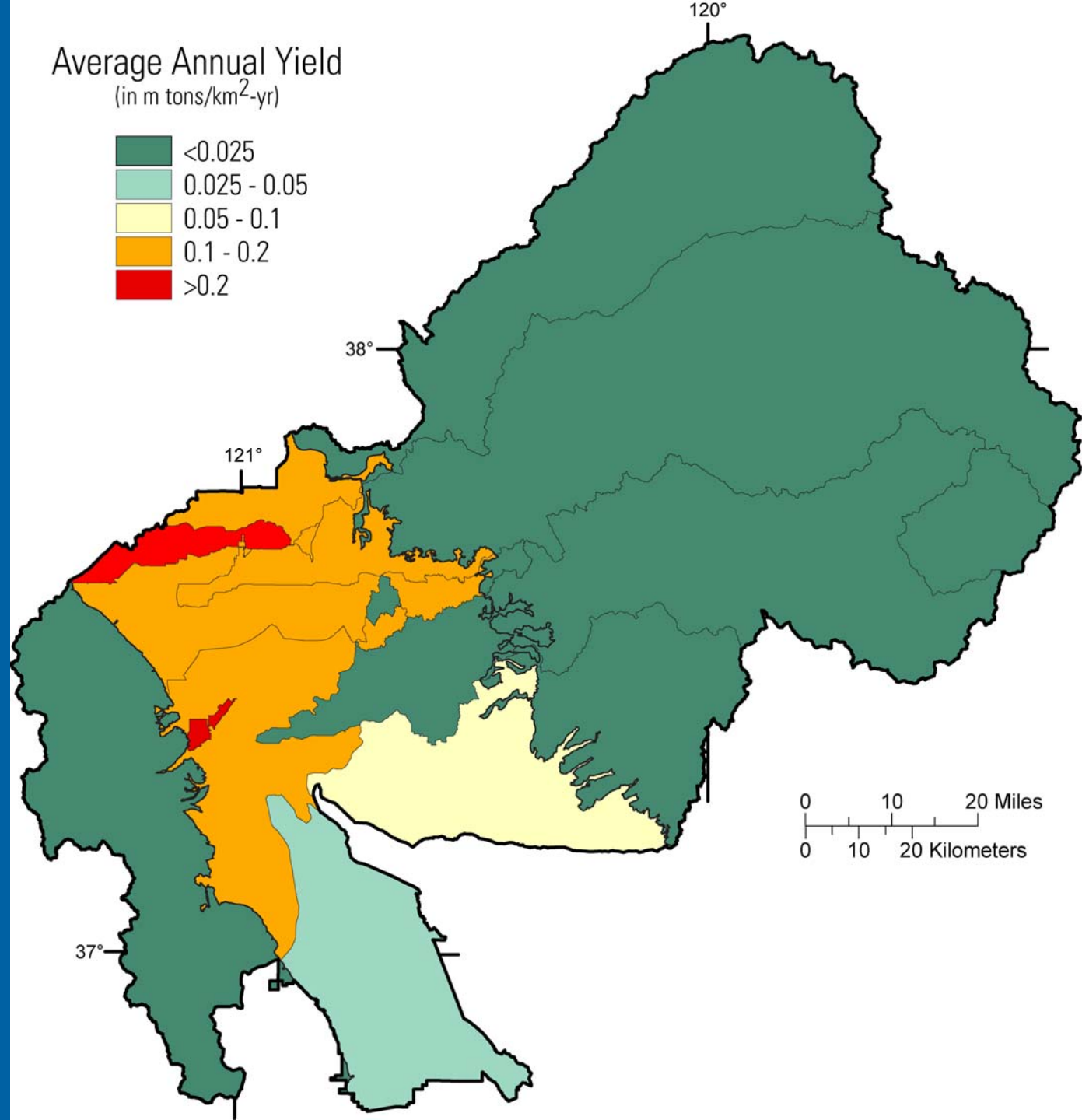
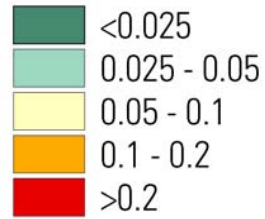
Average Annual Yield  
(in m tons/km<sup>2</sup>-yr)





Yields of TP  
by drainage  
basin, in  
categories of  
<0.025; 0.025-  
0.05; 0.05-0.1;  
0.1-0.2; and  
>0.2 metric  
tons/km<sup>2</sup>-yr

Average Annual Yield  
(in m tons/km<sup>2</sup>-yr)



# Percent Delivery in SJR

TN	TP	Diazinon	Chlorpyrifos
4.2%	3.4%	0.20%	0.01%

- o 2000-level, indirect loads and sources only
- o from USGS reports of loads and applications for January-February 2000, January-February 2001, and April-August 2001

# Conclusions

- Increasing nitrate trend, decreasing ammonia and phosphorus trends at SJR basin outlet
- Manure and fertilizer (indirect sources) have increased and point sources (direct sources) have decreased from 1985 to 2004
- Direct sources are very small part of total sources (1.6 % for TN, 0.4 % for TP) but contribute 27.3 % (TN) and 11.3 % (TP) of 2000-level loads in SJR
- Basins with highest yields are: Orestimba Creek (TN and TP) and drainage direct to SJR between Maze and Vernalis (TP)
- Percent delivery of indirect sources to SJR is 4.2% for TN; 3.4% for TP (compares to >>10% for NE basins for TN)
- Percent delivery of nutrients to SJR is >> pesticides